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FORM PTO-1390 (Rev 5-93) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: **NITROS P153US**

U.S.APPLICATION NO. (if known, see 37 C F R 1 5): 09/763925

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/CH99/00405	**September 1, 1998**	**September 1, 1998**

TITLE OF INVENTION

METHOD FOR INCREASING THERMAL CONVECTION SPEED IN A THERMOFUSIBLE POLYMER

APPLICANT(S) FOR DO/EO/US

Gianni BAFFELLI, Roberto MATTONE and Carlo RIVA

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ■ This is a FIRST submission of items concerning a filing under 35 U.S.C. 371.

2. ☐ This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371.

3. ■ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).

4. ■ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.

5. ■ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ■ has been transmitted by the International Bureau. (PCT/IB/308 mailed **March 9, 2000**)
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)

6. ■ A translation of the International Application into English (35 U.S.C. 371(c)(2)) is attached.

7. ■ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ■ have not been made and will not be made.

8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).

9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).

10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98 with PTO FORM 1449.

12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.

13. ■ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.

14. ☐ A substitute specification.

15. ☐ A change of power of attorney and/or address letter.

16. ■ Other items or information:

☐ Preliminary Examination Report	☐ Copy of Request
☐ Annexes to Pre. Ex. Rep.	☐ __ sheets of formal drawings
☐ International Search Report	■ Abstract
☐ German Novelty Search Report	■ **Applicant Claims Small Entity Status**
☐ ___ copies of citations	☐ Copy of Notification of File Missing Parts
■ Form PCT/IB/308	☐ German Language Specification
■ International Publ. No. WO 00/12279 (Face page only)	

CERTIFICATION UNDER 37 CFR 1.10

I hereby certify that this Transmittal Letter and the papers indicated as being transmitted therewith is being deposited with the United States Postal Service on this date **February 28, 2001** in an envelope as "Express Mail Post Office to Addressee" Mailing Label Number EL469354777US addressed to the: Commissioner of Patents and Trademarks, Washington, D.C. 20231.

Scott A. Daniels
(typed or printed name of person mailing paper)

(signature of person mailing paper)

17. ■ The following fees are submitted:				CALCULATIONS	PTO USE ONLY
Basic National Fee (37 CFR 1.492(a)(1)-(5)): Search Report has been prepared by the EPO or JPO .... $860.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) ..... $690.00 No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)). .... $710.00 Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO .... $1000.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) $100.00				09/763925	
ENTER APPROPRIATE BASIC FEE AMOUNT =				860	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				0	
Claims	Number Filed	Number Extra	Rate		
Total Claims	7-20 =	0	x $18.00	0	
Independent Claims	1-3 =	0	x $80.00	0	
Multiple dependent claim(s) (if applicable)			+ $270.00	0	
TOTAL OF ABOVE CALCULATIONS =				860	
Reduction by 1/2 for filing by small entity, if applicable. **Applicant Claims Small Entity Status.** (Note 37 CFR 1.9, 1.27, 1.28).				430	
SUBTOTAL =				430	
Processing fee of $130.00 for furnishing the English translation later the ☐ 20 ☐30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				0	
TOTAL NATIONAL FEE =				0	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property +				0	
TOTAL FEES ENCLOSED =				430	
				Amount to be: refunded	$
				charged	$

a. ■ A check in the amount of $ 430 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. 04-0213 in the amount of $____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ■ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 04-0213. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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09/763929

PTO/PCT Rec'd 2001

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	:	Gianni BAFFELLI, Roberto MATTONE and Carlo RIVA
Serial no.	:	
For	:	METHOD FOR INCREASING THERMAL CONVECTION SPEED IN A THERMOFUSIBLE POLYMER
Docket	:	NITROS P153US

BOX PCT
The Commissioner of Patents and Trademarks
Washington, D.C. 20231

PRELIMINARY AMENDMENT

Dear Sir:

By way of preliminary amendment, please amend the above identified application as set forth below.

In the Specification:

In accordance with 37 C.F.R. 1.111 and 1.121, a clean version of the specification and claims having appropriate changes is submitted along with a marked up copy of the original specification with all changes shown.

In the Claims:

Please cancel original claims 1 - 7, in favor of new claims 8 - 14 as submitted with the clean copy of the specification.

REMARKS

Please enter the above before consideration of this application.

In the event that there are any fee deficiencies or additional fees are payable, please charge the same or credit any overpayment to our Deposit Account (Account No. 04-0213).

Respectfully submitted,

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METHOD FOR INCREASING THERMAL CONVECTION SPEED IN A THERMOFUSIBLE POLYMER

FIELD OF THE INVENTION

The present invention concerns a method for increasing thermal convection in a thermofusible polymer.

BACKGROUND OF THE INVENTION

In heating polymers there is a preliminary phase preparatory to processing the polymers with heat formation or blow molding. It usually consists of exposing the polymers to an exterior source of thermal radiation. The temperature of the mass of polymer rises progressively through convection according to a downward angled slope. At the outset of the polymer's exposure to the source of thermal radiation, the temperature in the area closest to the source is higher than the area farther away. Progressively, the temperature difference between the nearby area and the distant area attenuates. Heat transmission occurs by convection over a period of time that depends specifically upon the source temperature and the thickness of the material.

The length of time required for the temperature of the entire mass of polymer to rise depends upon the process for shaping the material. Reducing this time increases production and profits.

SUMMARY OF THE INVENTION

The present invention proposes a method for reducing the time required for convection heating of a mass of thermofusible polymer.

This objective is achieved by the method in that the polymer is simultaneously exposed to at least one source of thermal radiation and to ultrasonic vibrations. The ultrasonic vibrations are transmitted to the thermofusible polymer by the direct application to a surface of the polymer of at least one sonotrode which is supplied by an ultrasound generator.

Besides increasing the transmission of heat through the polymer wall, the application of ultrasonic vibrations and simultaneous exposure to a

source of thermal radiation results in reorganization of the polymer molecules, favoring orientation of the molecules in a predetermined direction.

In a preferred embodiment, one surface of the polymer is exposed to a first source of thermal radiation and the opposite surface of the polymer is exposed to a second source of thermal radiation.

This allows for modulating the temperature differential between the opposing polymer surfaces exposed to the two sources of thermal radiation. It is possible to also improve the physical properties of the polymer and vary the heat transmission according to the polymer's shape, mass, and type.

Preferably, the ultrasonic vibrations are transmitted to the thermofusible polymer by placing at least one sonotrode in contact with a liquid intermediary which is in contact with one surface of the polymer.

The thermal radiation sources range in temperature from 100° to 500° C and the ultrasonic vibration frequency ranges from 15 to 60 kHz.

Advantageously, the duration of exposure to the thermal radiation source ranges from 1 to 10 seconds and preferably equals about 3 seconds.

In another embodiment, the ultrasonic vibrations are applied intermittently. This variation allows for modulating the speed of heat transmission through the polymer.

The present invention will be better understood with reference to the description of one preferred embodiment, which it not limitative, of the method and its variations.

When a mass of synthetic material, particularly an object made of thermofusible polymer, is exposed to a source of thermal radiation, the temperature of the mass rises progressively; inside the mass there is an observable temperature gradient defined by a generally linear curve with a negative slope. The simultaneous application of ultrasonic vibrations has the effect of either reducing the slope of the curve, eliminating it, or reversing the temperature gradient.

In practice, this translates into increasing heat transmission through the polymer mass, such that the wall of the object farthest away from the heat radiation source, after a very short period of time, reaches a higher temperature than the wall closest to the source.

In order to achieve this, the thermofusible polymer is exposed simultaneously to at least one source of thermal radiation and to ultrasonic vibrations. To transmit these vibrations to the polymer, a sonotrode supplied by an ultrasound generator can be applied directly to one of the surfaces of the polymer.

Various other embodiments of the method may be practiced. One of these variations consists of exposing one surface of the polymer to a first source of thermal radiation, exposing the opposite surface to a second source of thermal radiation, and simultaneously applying ultrasonic vibrations.

Ultrasonic vibrations may also be transmitted indirectly to the polymer by placing the sonotrode in contact with a liquid intermediary which is in contact with a surface of the polymer.

In all these variations, the radiation sources range in temperature from 100° to 500° C and the frequency of the ultrasonic vibrations transmitted ranges from 15 to 60 kHZ.

It has been observed that for products made of thermofusible polymer such as polyethylene terephthalate (PET) that is several millimeters thick, the required length of time for exposure to a source of thermal radiation in preparation for the thermoformation process ranges from 1 to 10 seconds and preferably equals about 3 seconds.

Furthermore, the polyethylene terephthalate does not undergo any crystallization at a temperature equal to or higher than the vitreous transition temperature, which is generally above 70° C.

Finally, it is noted that the structure becomes anisotropic and the molecular chains of the thermofusible polymers are oriented in the preferred direction parallel to the axis of propagation of the ultrasonic vibrations.

These phenomena prevent ultrasonic propagation in the material from stopping once vitreous transition is attained.

These results are further improved by applying the ultrasonic vibrations intermittently. The direction of the ultrasonic vibration propagation axis is chosen as a function of the geometry of the objects for thermoformation. If the objects are elongated, the ultrasound is preferably applied in a direction corresponding to the longest portion of the objects. The molecular chains align themselves in this direction and favor propagation of ultrasonic vibration.

Claims

8. A method for increasing thermal convection speed in a thermofusible polymer, wherein said polymer is simultaneously exposed to at least one source of thermal radiation and to ultrasonic vibrations, and in that said ultrasonic vibrations are transmitted to said thermofusible polymer by applying directly to one surface of said polymer at least one sonotrode supplied by an ultrasound generator.

9. The method according to claim 8, wherein one surface of said polymer is exposed to a first source of thermal radiation and the opposite surface of said polymer to a second source of thermal radiation.

10. The method according to claim 8, wherein said ultrasonic vibrations are transmitted to said thermofusible polymer by placing at least one sonotrode in contact with a liquid intermediary which is in contact with one surface of said polymer.

11. The method according to claim 8, wherein said sources of thermal radiation range in temperature from 100° to 500° C.

12. The method according to claim 8, wherein the frequency of the ultrasonic vibrations transmitted ranges from 15 to 60 kHz.

13. The method according to claim 8, wherein the thermofusible polymer is a polyethylene terephthalate, characterized in that the duration of exposure to the thermal radiation source ranges from 1 to 10 seconds and preferably equals approximately 3 seconds.

14. The method according to claim 8, wherein the ultrasonic vibrations are applied intermittently.

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METHOD FOR INCREASING THERMAL CONVECTION SPEED IN A THERMOFUSIBLE POLYMER

~~Technical Domain~~

FIELD OF THE INVENTION

The present invention concerns a method for increasing thermal convection in a thermofusible polymer.

BACKGROUND OF THE INVENTION~~Prior Art~~

In heating polymers there is a preliminary phase preparatory to processing the polymers with heat formation or blow molding. It usually consists of exposing the polymers to an exterior source of thermal radiation. The temperature of the mass of polymer rises progressively through convection according to a downward angled slope. At the outset of the polymer's exposure to the source of thermal radiation, the temperature in the area closest to the source is higher than the area farther away. Progressively, the temperature difference between the nearby area and the distant area attenuates. Heat transmission occurs by convection over a period of time that depends specifically upon the source temperature and the thickness of the material.

The length of time required for the temperature of the entire mass of polymer to rise depends upon the process for shaping the material. Reducing this time increases production and profits.

~~Description of the Invention~~SUMMARY OF THE INVENTION

The present invention proposes a method for reducing the time required for convection heating of a mass of thermofusible polymer.

This objective is achieved by the method the polymer is simultaneously exposed to at least one source of thermal radiation and to ultrasonic vibrations. The ultrasonic vibrations are transmitted to the thermofusible polymer by the direct application to a surface of the polymer of at least one sonotrode which is supplied by an ultrasound generator.

Besides increasing the transmission of heat through the polymer wall, the application of ultrasonic vibrations and simultaneous exposure to a

source of thermal radiation results in reorganization of the polymer molecules, favoring orientation of the molecules in a predetermined direction.

In a preferred embodiment, one surface of the polymer is exposed to a first source of thermal radiation and the opposite surface of the polymer is exposed to a second source of thermal radiation.

This allows for modulating the temperature differential between the opposing polymer surfaces exposed to the two sources of thermal radiation. It is possible to also improve the physical properties of the polymer and vary the heat transmission according to the polymer's shape, mass, and type.

Preferably, the ultrasonic vibrations are transmitted to the thermofusible polymer by placing at least one sonotrode in contact with a liquid intermediary which is in contact with one surface of the polymer.

The thermal radiation sources range in temperature from 100° to 500° C and the ultrasonic vibration frequency ranges from 15 to 60 kHz.

Advantageously, the duration of exposure to the thermal radiation source ranges from 1 to 10 seconds and preferably equals about 3 seconds.

In another embodiment, the ultrasonic vibrations are applied intermittently. This variation allows for modulating the speed of heat transmission through the polymer.

The present invention will be better understood with reference to the description of one preferred embodiment, which it not limitative, of the method and its variations.

When a mass of synthetic material, particularly an object made of thermofusible polymer, is exposed to a source of thermal radiation, the temperature of the mass rises progressively; inside the mass there is an observable temperature gradient defined by a generally linear curve with a negative slope. The simultaneous application of ultrasonic vibrations has the effect of either reducing the slope of the curve, eliminating it, or reversing the temperature gradient.

In practice, this translates into increasing heat transmission through the polymer mass, such that the wall of the object farthest away from the heat radiation source, after a very short period of time, reaches a higher temperature than the wall closest to the source.

In order to achieve this, the thermofusible polymer is exposed simultaneously to at least one source of thermal radiation and to ultrasonic vibrations. To transmit these vibrations to the polymer, a sonotrode supplied by an ultrasound generator can be applied directly to one of the surfaces of the polymer.

Various other embodiments of the method may be practiced. One of these variations consists of exposing one surface of the polymer to a first source of thermal radiation, exposing the opposite surface to a second source of thermal radiation, and simultaneously applying ultrasonic vibrations.

Ultrasonic vibrations may also be transmitted indirectly to the polymer by placing the sonotrode in contact with a liquid intermediary which is in contact with a surface of the polymer.

In all these variations, the radiation sources range in temperature from 100° to 500° C and the frequency of the ultrasonic vibrations transmitted ranges from 15 to 60 kHZ.

It has been observed that for products made of thermofusible polymer such as polyethylene terephthalate (PET) that is several millimeters thick, the required length of time for exposure to a source of thermal radiation in preparation for the thermoformation process ranges from 1 to 10 seconds and preferably equals about 3 seconds.

Furthermore, the polyethylene terephthalate does not undergo any crystallization at a temperature equal to or higher than the vitreous transition temperature, which is generally above 70° C.

Finally, it is noted that the structure becomes anisotropic and the molecular chains of the thermofusible polymers are oriented in the preferred direction parallel to the axis of propagation of the ultrasonic vibrations.

These phenomena prevent ultrasonic propagation in the material from stopping once vitreous transition is attained.

These results are further improved by applying the ultrasonic vibrations intermittently. The direction of the ultrasonic vibration propagation axis is chosen as a function of the geometry of the objects for thermoformation. If the objects are elongated, the ultrasound is preferably applied in a direction corresponding to the longest portion of the objects. The molecular chains align themselves in this direction and favor propagation of ultrasonic vibration.

Claims

~~1. A method for increasing thermal convection speed in a thermofusible polymer, characterized in that said polymer is simultaneously exposed to at least one source of thermal radiation and to ultrasonic vibrations, and in that said ultrasonic vibrations are transmitted to said thermofusible polymer by applying directly to one surface of said polymer at least one sonotrode supplied by an ultrasound generator.~~

~~2. The method according to claim 1 characterized in that one surface of said polymer is exposed to a first source of thermal radiation and the opposite surface of said polymer to a second source of thermal radiation.~~

~~3. The method according to claim 1 characterized in that said ultrasonic vibrations are transmitted to said thermofusible polymer by placing at least one sonotrode in contact with a liquid intermediary which is in contact with one surface of said polymer.~~

~~4. The method according to claims 1 and 2 characterized in that said sources of thermal radiation range in temperature from 100° to 500° C.~~

~~5. The method according to claim 1 characterized in that the frequency of the ultrasonic vibrations transmitted ranges from 15 to 60 kHz.~~

~~6. The method according to claim 1 wherein the thermofusible polymer is a polyethylene terephthalate, characterized in that the duration of exposure to the thermal radiation source ranges from 1 to 10 seconds and preferably equals approximately 3 seconds.~~

~~7. The method according to claim 1 characterized in that the ultrasonic vibrations are applied intermittently.~~

<u>8. A method for increasing thermal convection speed in a thermofusible polymer, wherein said polymer is simultaneously exposed to at least one source of thermal radiation and to ultrasonic vibrations, and in that said ultrasonic vibrations are transmitted to said thermofusible polymer by applying directly to one surface of said polymer at least one sonotrode supplied by an ultrasound generator.</u>

9. The method according to claim 8, wherein one surface of said polymer is exposed to a first source of thermal radiation and the opposite surface of said polymer to a second source of thermal radiation.

10. The method according to claim 8, wherein said ultrasonic vibrations are transmitted to said thermofusible polymer by placing at least one sonotrode in contact with a liquid intermediary which is in contact with one surface of said polymer.

11. The method according to claim 8, wherein said sources of thermal radiation range in temperature from 100° to 500° C.

12. The method according to claim 8, wherein the frequency of the ultrasonic vibrations transmitted ranges from 15 to 60 kHz.

13. The method according to claim 8, wherein the thermofusible polymer is a polyethylene terephthalate, characterized in that the duration of exposure to the thermal radiation source ranges from 1 to 10 seconds and preferably equals approximately 3 seconds.

14. The method according to claim 8, wherein the ultrasonic vibrations are applied intermittently.

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METHOD FOR INCREASING THERMAL CONVECTION SPEED IN A THERMOFUSIBLE POLYMER

Technical Domain

The present invention concerns a method for increasing thermal convection speed in a thermofusible polymer.

Prior Art

In heating polymers there is a preliminary phase preparatory to processing the polymers with heat formation or blow molding. It usually consists of exposing the polymers to an exterior source of thermal radiation. The temperature of the mass of polymer rises progressively through convection according to a downward angled slope. At the outset of the polymer's exposure to the source of thermal radiation, the temperature in the area closest to the source is higher than the area farther away. Progressively, the temperature difference between the nearby area and the distant area attenuates. Heat transmission occurs by convection over a period of time that depends specifically upon the source temperature and the thickness of the material.

The length of time required for temperature of the entire mass of polymer to rise conditions the process for shaping the material. Reducing this time increases production profits.

Description of the Invention

The present invention proposes a method for reducing the time required for convection heating of a mass of thermofusible polymer.

This objective is achieved by the method described in the preamble, characterized in that said polymer is simultaneously exposed to at least one source of thermal radiation and to ultrasonic vibrations, and in that said ultrasonic vibrations are transmitted to said thermofusible polymer by the direct application to a surface of said polymer of at least one sonotrode which is supplied by an ultrasound generator.

Besides increasing the transmission speed of heat through the polymer wall, the application of ultrasonic vibrations and simultaneous

exposure to a source of thermal radiation results in reorganization of the polymer molecules, favoring orientation of the molecules in a predetermined direction.

According to a first variation, one surface of said polymer is exposed to a first source of thermal radiation and the opposite surface of said polymer is exposed to a second source of thermal radiation.

Because of this, it is possible to modulate the temperature differential between the two opposite polymer surfaces exposed to two sources of thermal radiation. It is also possible to improve the physical properties of the polymer and to vary the heat transmission speed according to the polymer's shape, mass, and type.

Preferably, said ultrasonic vibrations are transmitted to said thermofusible polymer by placing at least one sonotrode in contact with a liquid intermediary which is in contact with one surface of said polymer.

Preferably, said thermal radiation sources range in temperature from 100° to 500° C and the ultrasonic vibration frequency ranges from 15 to 60 kHz.

Advantageously, the duration of exposure to the thermal radiation source ranges from 1 to 10 seconds and preferably equals about 3 seconds.

According to a particularly interesting method of proceeding, the ultrasonic vibrations are applied intermittently.

This variation also provides for modulating the speed of heat transmission through the polymer.

The present invention will be better understood with reference to the description of one preferred embodiment, which it not limitative, of the method and its variations.

How to Carry Out the Invention

When a mass of synthetic material, particularly an object made of thermofusible polymer, is exposed to a source of thermal radiation, the temperature of the mass rises progressively; inside the mass there is an

observable temperature gradient defined by a generally linear curve with a negative slope. The simultaneous application of ultrasonic vibrations has the effect of either reducing the slope of the curve, eliminating it, or reversing it.

In practice, this translates into an increased speed of heat transmission through the polymer mass, such that the wall of the object farthest away from the heat radiation source after a very short period of time reaches a higher temperature than the wall closest to the source.

In order to achieve this, the thermofusible polymer is exposed simultaneously to at least one source of thermal radiation and to ultrasonic vibrations. To transmit these vibrations to the polymer, a sonotrode supplied by an ultrasound generator can be applied directly to one of the surfaces of the polymer.

Various other embodiments of the method may be practiced. One of these variations consists of exposing one surface of the polymer to a first source of thermal radiation, exposing the opposite surface to a second source of thermal radiation, and simultaneously applying ultrasonic vibrations.

Ultrasonic vibrations may also be transmitted indirectly to the polymer by placing the sonotrode in contact with a liquid intermediary which is in contact with a surface of the polymer.

In all these variations, the radiation sources range in temperature from 100° to 500° C and the frequency of the ultrasonic vibrations transmitted ranges from 15 to 60 kHZ.

It has been observed that for products made of thermofusible polymer such as polyethylene terephthalate (PET) that is several millimeters thick, the required length of time for exposure to a source of thermal radiation in preparation for the thermoformation process ranges from 1 to 10 seconds and preferably equals about 3 seconds.

Furthermore, said polyethylene terephthalate does not undergo any crystallization at a temperature equal to or higher than the vitreous transition temperature, which is generally above 70° C.

Finally, it is noted that the structure become anisotropic and the molecular chains of the thermofusible polymers are oriented in the preferred direction parallel to the axis of propagation of the ultrasonic vibrations. These phenomena prevent ultrasonic propagation in the material from stopping once vitreous transition is attained.

These results are further improved by applying the ultrasonic vibrations intermittently. The direction of the ultrasonic vibration propagation axis is chosen as a function of the geometry of the objects for thermoformation. If they are elongated objects, the ultrasound is preferably applied in a direction corresponding to the longest portion of the objects. The molecular chains align themselves in this direction and favor propagation of ultrasonic vibration.

Claims

1. A method for increasing thermal convection speed in a thermofusible polymer, characterized in that said polymer is simultaneously exposed to at least one source of thermal radiation and to ultrasonic vibrations, and in that said ultrasonic vibrations are transmitted to said thermofusible polymer by applying directly to one surface of said polymer at least one sonotrode supplied by an ultrasound generator.

2. The method according to claim 1 characterized in that one surface of said polymer is exposed to a first source of thermal radiation and the opposite surface of said polymer to a second source of thermal radiation.

3. The method according to claim 1 characterized in that said ultrasonic vibrations are transmitted to said thermofusible polymer by placing at least one sonotrode in contact with a liquid intermediary which is in contact with one surface of said polymer.

4. The method according to claims 1 and 2 characterized in that said sources of thermal radiation range in temperature from 100° to 500° C.

5. The method according to claim 1 characterized in that the frequency of the ultrasonic vibrations transmitted ranges from 15 to 60 kHz.

6. The method according to claim 1 wherein the thermofusible polymer is a polyethylene terephthalate, characterized in that the duration of exposure to the thermal radiation source ranges from 1 to 10 seconds and preferably equals approximately 3 seconds.

7. The method according to claim 1 characterized in that the ultrasonic vibrations are applied intermittently.

METHOD FOR INCREASING THERMAL CONVECTION SPEED IN A THERMOFUSIBLE POLYMER

Abstract of the Disclosure

The invention concerns a method for increasing thermal convection speed in a thermofusible polymer, in particular a polyethylene terephthalate, enabling to increase the speed of heat transmission by thermal convection in the polymer, by exposing it simultaneously to at least a thermal radiation source and ultrasonic vibrations. Th ultrasonic vibrations are preferably applied intermittently on a surface of the polymer via a sonotrode supplied by an ultrasound generator, either directly, or via a liquid in contact with the polymer. Thus the physical characteristics of the polymer can be improved and the heat transmission speed can be varied depending on its form, mass and type.,

COMBINED DECLARATION AND POWER OF ATTORNEY

(Original, Design, National Stage of PCT, Supplemental)

As a below named inventor, I hereby declare that:

TYPE OF DECLARATION

This declaration is of the following type: (check one applicable item below)

- ☐ original
- ☐ design
- ☐ supplemental
- ■ National Stage of PCT
- ☐ divisional (see added page)
- ☐ continuation (see added page)
- ☐ continuation-in-part (see added page)

INVENTORSHIP IDENTIFICATION

My residence, post office address and citizenship are as stated below next to my name. I believe that the original, first and sole inventor *(if only one name is listed below)* an original, first and joint inventors *(if plural names are listed below)* of the subject matter that is claimed, and for which a patent is sought on the invention entitled:

TITLE OF INVENTION

METHOD FOR INCREASING THERMAL CONVECTION SPEED IN A THEMOFUSIBLE POLYMER

SPECIFICATION IDENTIFICATION

The specification of which: (complete (a), (b) or (c))

(a) ☐ is attached hereto.
(b) ☐ was filed on ____________ as ☐ Serial No. 0 / ______ or
☐ Express Mail No. ____________________ as Serial No. (not yet known) and was amended on ____________ (if applicable).
(c) ■ was described and claimed in PCT International Application No. PCT/CH99/00405 filed on 09/01/1999 and as amended under PCT Article 19 on ________________________ (if any).
(d) ☐ amended on ____.

POWER OF ATTORNEY

As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (list name(s) and registration number(s))

Anthony G. M. Davis	Registration No. 27,868
Michael J. Bujold	Registration No. 32,018
Scott A, Daniels	Registration No. 42,462

☐ Attached as part of this Declaration and Power of Attorney is the authorization of the above-named attorney(s) to accept and follow instructions from my representative(s).

Send Correspondence to

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Manchester, NH 03101-1151

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Direct Telefaxes to (603) 624-9229

BR 9322 US

ACKNOWLEDGMENT OF REVIEW OF PAPERS AND DUTY OF CANDOR

I/We hereby state that I/we have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I/We acknowledge the duty to disclose to the United States Patent Office all information which is known to be material to patentability of this application as defined in § 1.56 of Title 37 of the Code of Federal Regulations.

PRIORITY CLAIM

I/We hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me/us on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

EARLIEST FOREIGN APPLICATION(S), IF ANY FILED WITHIN 12 MONTHS (6 MONTHS FOR DESIGN) PRIOR TO THIS U.S. APPLICATION

COUNTRY	APPLICATION NO.	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 37 USC 119
FRANCE	98 11212	01 septembre 98	☒YES ☐NO
			☐YES ☐NO
			☐YES ☐NO
			☐YES ☐NO
			☐YES ☐NO

ALL FOREIGN APPLICATION(S), IF ANY FILED MORE THAN 12 MONTHS (6 MONTHS FOR DESIGN) PRIOR TO THIS U.S. APPLICATION

____

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☐ I/We hereby claim the benefit, under 35 U.S.C. 119(e), of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YY)	☐ Additional provisional application numbers are listed on a supple-mental priority data sheet PTO/SB/02B attached hereto.

DECLARATION

I/We hereby declare that all statements made herein of my/our own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

1-00

Full name of ~~sole or~~ first joint inventor: BAFFELLI Gianni

Inventor's signature: ______________ Date: 14-04-2001

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09763025.030901

2a. Full name of second joint inventor: MATTONE Roberto

Inventor's signature: ________ Date: 14-04-2001

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3a Full name of third joint inventor: RIVA Carlo

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Full name of fourth joint inventor: ________

Inventor's signature: ________ Date: ________

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Full name of fifth joint inventor: ________

Inventor's signature: ________ Date: ________

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Post Office Address: Same as above Country of Citizenship: ________

Full name of sixth joint inventor: ________

Inventor's signature: ________ Date: ________

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Post Office Address: Same as above Country of Citizenship: ________

Full name of seventh joint inventor: ________

Inventor's signature: ________ Date: ________

Residence: ________

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Full name of eighth joint inventor: ________

Inventor's signature: ________ Date: ________

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Full name of ninth joint inventor: ________

Inventor's signature: ________ Date: ________

Residence: ________

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Full name of tenth joint inventor: ________

Inventor's signature: ________ Date: ________

Residence: ________

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